IV. "On the Spark Spectrum of Argon as it appears in the Spark Spectrum of Air." By W. N. HARTLEY, F.R.S., Professor of Chemistry, Royal College of Science, Dublin. Received January 31, 1895. [Revised February 18, 1895.]

The spark spectrum of air as photographed, mapped, and described by Hartley and Adeney* contains various lines which they have not been able to attribute to oxygen or to nitrogen, having no grounds for assigning them to one element or the other. The lines belonging to oxygen and nitrogen, when produced by uncondensed sparks, are comparatively well known; so also are the lines of oxygen when a condensed spark is used, but it is otherwise with the lines of nitrogen when the spark is condensed.

It was observed by one of us† that the very abundant air lines in the photographed spectrum of air were subject to considerable variations according to circumstances. Thus, by modifications in manipulation, the air-spectrum might almost be suppressed, though the metallic lines remained strong.

On the other hand, it was remarked that certain metallic electrodes gave spectra of air with some lines more prominent than others, also more sharply and distinctly defined. Aluminium and copper were two which gave the most distinctly-marked air-lines. Platinum also in some cases.

From statements contained in the paper contributed by Mr. Crookes on the spectrum of argon it may be gathered that the following conditions have been observed to yield the brightest and purest spectrum of argon:—

1. As to pressure, about 3 mm.
2. Electrodes of aluminium or platinum.
3. A condensed spark from a coil and Leyden jar.

These conditions were very nearly approached when Hartley and Adeney's spectra of air were photographed, thus:—

1. As argon is about 1 per cent. of the atmosphere, its partial pressure is about 7·5 mm.
2. Electrodes of aluminium, copper, platinum, and palladium were used.
3. A condensed spark was always employed, this being produced by using a coil and Leyden jar.

It was therefore reasonable to expect that the spectrum of the

* 'Phil. Trans.,' vol. 175, p. 63, 1884.

† 'Journ. Chem. Soc.,' vol. 41, p. 84, 1882; also 'Sci. Trans. Royal Dublin Soc.,' vol. 1, p. 231 (new series), 1881.

blue and ultra-violet rays emitted by argon would be recognised among some of the weaker lines in the spectrum of air. When operating in a tube closed by a plate of quartz with oxygen, carbon dioxide, nitrogen, and other gases, with carbon electrodes and points of aluminium, the variations in the spectrum were considered to be of the same nature as those described in the 'Roy. Soc. Proc.,' vol. 55, p. 344, 1894, but it appears now to be extremely probable that they were in some cases due to the removal of nitrogen and the development of the argon spectrum. Accordingly the spark spectrum of air has been examined* for those lines more refrangible than 4674, since, if it be an elementary form of matter, they must appear there, or some explanation should be given to accouut for their absence.

It may here be stated that the photographs were taken in 1882 with a Rutherford diffraction grating with 14,000 lines to the inch and quartz lenses of 36 inches focus. Two sets of measurements were made, one from the photograph of each metal; where the lines did not agree, sometimes a third set of measurements were made from another plate, but when this was not necessary the mean value was adopted as the wave-length. The maximum error for well-defined lines was believed to be not greater than $\pm 0 \cdot 3$ of a tenth metre; for faint lines it is larger, but it seldom rises to more than 0·5. The metre of Ångström was our standard.

The following table gives the lines in the red and in the blue spectra of argon, and the corresponding lines in the spectrum of air. With the exception of two lines printed in italics, the latter are all absolute wave-lengths.

Column I.—The spectrum of the red rays of argon.
,, II.—The spectrum of the blue rays of argon.
,, III.—Hartley and Adeney's spectrum of air, with the non-coincident lines omitted.

I.	II.	III.	
4629·5		4628·9	Strong.
	4608	4605·6	Weak.
4594·5		4595·0	Weak.
	4586·9	4589·3	Weak.
	4543·5	4543·4	Faint.
4509·5	4509·5	4506·6	Weak.
4478·3		4476·6	Weak, fine.
4426·5		4425·9	Weak, nebulous.
4399·5		4402·6	Faint.
4376·5		4378·0	Faint.
4348·5		4348·2	Strong.
	4345·0	4343·9	Weak, fine.
4333·5	4333·5	{4335·9	Faint.
		4330·8}	Faint.

* 'Phil. Trans.,' vol. 175, p. 63, 1884.

I.	II.	III.	
	4300·5	4302·0	Very faint.
4299·0			
4277·0		4275·3	Faint, nebulous.
4272·0	4272·0	4274·3	Very faint, sharp.
4266·0	4266·0	4265·4	Very faint.
4251·5	4251·5	4253·4	Faint.
4228·5		4228·9	Fairly strong, nebulous.
4201·0	4201·0	4206·3	Faint, nebulous.
4198·0	4198·0	4197·9	Faint, nebulous.
4191·5	4191·5	4189·3	Weak, sharp.
4183·0	4183·0	4185·1	Weak, sharp.
4164·5	4164·5	4169·2	Weak, nebulous.
4159·5	4159·5	4157·9	Very faint, nebulous.
	4131·5	4132·8	Fairly strong, fine.
	4105·0	4104·3	Fairly strong, fine.
		4102·6	Fairly strong, fine.
	4072·5	4071·4	Strong, fine.
	4033·0	4034·4	Weak, nebulous.
	3967·8	3967·3	Faint, fine.
	3943·5	3944·5	Faint, nebulous.
	3931·8	3932·9	Very faint.
	3928·5	3929·0	Very faint.
	3892·0	3892·4	Very faint.
	3851·5	3850·0	Faint, fine.
	3803·5	3804·0	Faint, fine.
(3771·5)	3780·8	3782·1	Faint, fine.
	3770·5	3771·5	Faint, fine.
	3738·5	3739·7	Very faint, fine.
	3729·8	3726·6	Strong, fine.
	3587·0	3589·6	Weak, fine.
	3580·3	3583·7	Weak, fine.
	3575·0	3576·2	Weak, fine.
	3560·0	3560·6	Weak, nebulous.
	3544·5	3544·2	Weak, nebulous.
	3513·5	*3514·1*	Very faint, fine.
	3490·0	3490·7	Weak, fine.
	3475·7	3478·1	Faint, fine.
	3453·5	*3456·2*	Very faint, fine.
	3388·0	3389·9	Fairly strong, fine.
	3042·7	3042·5	Faint, fine.
	2734·5	2733·2	Faint, fine. Strongest in centre, thinning away at each end.

It will appear that these lines, which approximate so closely to a large number of lines in the argon spectrum, are scarcely likely to do so by mere chance. There is one group marked by a bracket which may be identified in the spectrum of aluminium in the 'J. Chem. Soc.,' vol. 41, p. 90 (photographs). It will be seen that, compared with others, the spectrum of aluminium No. 4 is rich in well-defined air lines, and the group of lines referred to is that lying immediately below the space between the most prominent lines in the first or least-refrangible triplet in the spectrum of cadmium No. 3. They

are well seen also in the indium spectrum No. 5 from 3850 to 3514·1. The enlargements of these prismatic spectra, however, cannot compare with the grating spectra, the air lines being, as far as possible, suppressed in the former.

I do not attribute much importance to the fact that argon gives two spectra; the red appears to be the spectrum of the first order, or the spectrum of the lower temperature which corresponds thereto; the blue is the line spectrum, or spectrum at the higher temperature.

I have photographed simultaneously from the same spark the two spectra of nitrogen as rendered by atmospheric air.

It is therefore more likely that argon is one substance and not two. Whether it is a compound or an element is a question into which the following considerations may enter. There are at present no gaseous substances known which can withstand the temperature of the condensed spark without exhibiting the spectra of one or other of the elements of which it is composed. If, therefore, argon were N_3 it would disclose the spectrum of nitrogen. As the spectrum is not that of any known substance, it follows that, if a compound, it must be a compound of a new element.

A Letter from Prof. FITZGERALD upon the Atomicity of Argon was read.

Presents, January 31, 1895.

Transactions.

Brussels:—Association Belge des Chimistes. Bulletin. Année VII. No. 8. 8vo. *Bruxelles* 1893. The Association.

Bucharest:—Societăţii de Sciinţe Fizice. Buletinul. Anul III. Nos. 5—8. Centenarul lui Lavoisier, 1794–1894. 4to. *Bucurescĭ* 1895. The Society.

Cracow:—Académie des Sciences. Bulletin International. Décembre. 8vo. *Cracovie* 1894. The Academy.

Edinburgh:—Royal Scottish Society of Arts. Transactions. Vol. XIII. Part 4. 8vo. *Edinburgh* 1894. The Society.

Royal Society. List of Members. 1894. 4to. [*Edinburgh.*] The Society.

Göttingen:—Königl. Gesell. der Wissenschaften. Nachrichten. 1894. No. 4. 8vo. *Göttingen* 1895. The Society.

Heidelberg:—Naturhistorisch-Medicinscher Verein. Verhandlungen. Neue Folge. Band 5. Heft 3. 8vo. *Heidelberg* 1894. The Society.